Analysis of CHAMP Ionospheric Measurements Using a Global Ionospheric Data Assimilation Model

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Abstract

The availability of GPS occultation measurements from the CHAMP satellite adds to the large body of ground GPS ionospheric data with the advantage of better vertical resolution. However, the standard "Abel transform" algorithm is problematic for CHAMP because of its low altitude. Moreover, the spherical symmetry assumption required in the Abel inversion is often not a good approximation of the ionosphere. Our approach has been to assimilate relative total electron content (TEC) measurements from CHAMP into a global assimilation model in a manner similar to what is done in the neutral atmosphere by numerical weather models.

A fully 3-dimensional Global Assimilative Ionosphere Model (GAIM) is currently being developed by a joint JPL and University of Southern California team. To estimate the electron density on a global grid, GAIM uses a first-principles ionospheric physics model ("forward" model) and one of two estimation techniques: the Kalman filter and 4DVAR (4-Dimensional VARiational). Because of the large dimension of the state (i.e., electron density on a global 3-D grid), implementation of a full Kalman filter is not computationally tractable. Therefore, we have implemented a band limited Kalman in which a full time propagation of the covariance is performed but only a portion of the covariance matrix is retained. The retained elements are determined based on assumed physical correlation lengths in the ionosphere.

The effectiveness of CHAMP occultations for specifying the ionosphere is assessed by assimilating CHAMP occultation and ground GPS data into GAIM and validating the electron density field against independent measurements. A series of such GAIM retrievals will be presented and validated by comparisons to: vertical TEC data from the TOPEX altimeter, slant TEC data from ground GPS sites that were not included in the assimilation runs, and global ionosonde data (FoF2, HmF2, and bottom-side profiles where available).